

Application No. 10/824,719
Technology Center 1795
Submission Accompanying RCE dated March 21, 2008

REMARKS

Please enter this Submission as part of the Request for Continued Examination (RCE) filed herewith under 37 CFR §1.114.

In response to the above-noted Office Action dated November 21, 2007, Applicants had submitted a reply filed on January 22, 2008. In the above-noted Advisory Action dated January 31, 2008, Applicants were notified that the amendments presented in Applicants' previous reply would not be entered for purposes of appeal.

For purposes of the present RCE, Applicants hereby request non-entry of their previously-submitted unentered reply filed on January 22, 2008, and instead present the amended claims set forth above.

In view of the above, claims 1-24 were pending in the above-identified US Patent Application immediately prior to the filing of the present Submission.

The following is an explanation of the amendments presented with this Submission.

Independent claims 1 and 8 have been amended to incorporate the limitations of dependent claim 3, namely, the inclusion of a housing (44) and a

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control system (20). In addition, claims 1 and 8 have been amended to require the presence of at least one passage (46,47) for conducting hydrogen gas into and out of the housing (44), and to recite that the hydrogen storage member(s) (50) also have exterior surfaces (inherent), at least the interior surfaces have "dangling bond sites at which reversible chemisorption of hydrogen atoms occurs," and the control system (20) is used for "liberating said chemisorbed hydrogen atoms from said dangling bond sites." Support for these amendments can be found in Applicants' specification at page 7, lines 9-11 (passage 46,47), page 12, lines 20-23, page 17, lines 4-5, and page 19, lines 5-11 (dangling/valence bonds), page 3, lines 5-9 (reversible, chemisorption), and page 8, lines 11-15 and 22-27, and page 9, lines 4-9 (liberated bonded hydrogen atoms).

Claim 1 has been further amended to use the term "mass" instead of "block" when describing the porous silicon.

Dependent claim 2 has been amended to correct a typographical error, and for consistency with its parent claim 1.

Dependent claim 3 has been amended to recite that the interior surfaces of the porous silicon are bare silicon surfaces at which said dangling bond sites are exposed. Support for these amendments can be found in

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Applicants' specification at page 19, line 9.

Dependent claim 15 has been amended for consistency with its parent claim 1.

Favorable reconsideration and allowance of claims 1-24 are respectfully requested in view of the above amendments and the following remarks.

In the previous Office and Advisory Actions, all of the pending claims stood rejected under 35 USC §102 or §103. Applicants provide the following responses to some of the arguments made in the Office and Advisory Actions.

Preamble

Applicants believe the recitation in the preambles of the independent claims requiring Applicants' claimed "system" as "storing and retrieving elemental hydrogen" must be accorded patentable weight because elements recited in the claim body are pointless if in fact the "system" is not "for storing and retrieving elemental hydrogen." Applicants note that, when considering what effect is to be given a claim's preamble language,

The preamble is not given the effect of a limitation unless it breathes life and meaning into the claim. . . . In claims directed to articles and apparatus, any phraseology in the

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preamble that limits the structure of that article or apparatus
must be given weight. (Emphasis added).

MPEP §2111.02

Furthermore,

“[C]lear reliance on the preamble during prosecution to distinguish the claimed invention from the prior art transforms the preamble into a claim limitation because such reliance indicates use of the preamble to define, in part, the claimed invention....

MPEP 2111.02.II., citing *Catalina Mktg. Int'l v. Coolsavings.com, Inc.*, 289 F.3d 801, 808, 62 USPQ2d 1781, 1785 (Fed. Cir. 2002).

Applicants' arguments set forth below clearly rely on the preamble of the independent claims “to distinguish the claimed invention from the prior art.” Therefore the preamble of each independent claims “breathes life and meaning into the claim,” such that (paraphrasing *In re Stencel*, 4 USPQ2d 1071 (Fed. Cir. 1987), cited at MPEP 2111.02.II.)

the framework - the teachings of the prior art - against which patentability is measured is not all [systems] broadly, but [systems] suitable for [storing and retrieving elemental hydrogen], for the claims are so limited.

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Rejections based on U.S. Pat. No. 5,882,496 to Northrup et al. (Northrup)

Independent claim 1 and its dependent claims 2-7 and 15-22 were rejected as anticipated by Northrup or unpatentable over Northrup alone or in further view of U.S. Patent No. 4,265,720 to Winstel, U.S. Patent No. 5,196,377 to Wagner et al. (Wagner), or U.S. Patent No. 5,360,461 to Meinzer. Applicants respectfully request reconsideration of these rejections in view of the amendments presented above as well as the following comments.

Dependent claim 3 was solely rejected under 35 USC §103 in view of the combination of Northrup and Winstel. Because claim 1 has been amended to incorporate all of the limitations of claim 3, Applicants believe that the rejections based on Northrup alone and Northrup combined with Wagner and Meinzer are overcome. Applicants believe the combination of Northrup and Winstel do not teach or suggest amended independent claim 1.

Northrup discloses a porous silicon layer 27 that adsorbs and desorbs a fluid (gas or liquid). However, Northrup merely uses this affect to actuate a membrane 26, and the silicon layer 27 is covered by a heater 28. Because Northrup's intent is to expand a fluid using heat in order to actuate the membrane 26, the benefit of using porous silicon is void volume, since more void volume allows more fluid to be absorbed and released. Therefore,

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and in contrast to Applicants' invention, the fluid adsorption required of Northrup's silicon layer 27 does not require any internal surfaces with a large number of exposed silicon dangling bonds at which chemisorption of hydrogen can occur. Nor does Northrup disclose or suggest removing the desorbed fluid from the cavity 25 into which it is released by the silicon layer 27. In fact, to do so would be contrary to the operation of Northrup's device 20.

Winstel consistently refers to hydrogen being absorbed by his silicon layer 2, and as such appears to suggest that hydrogen storage is by diffusion into the silicon layer 2. However, Applicants' invention is based on hydrogen adsorption by silicon, and specifically chemisorption, which is a surface phenomenon that involves dangling bonds (which Winstel appears to dismiss as irrelevant at column 2, lines 26-32). Because Winstel discloses hydrogen absorption, it would be contrary to Winstel to introduce porosity in his silicon layer 2, since doing so would reduce the amount of silicon available for hydrogen absorption.

Furthermore, Winstel repeatedly states that an extraneous means is used to "generate atomic hydrogen," which can then be absorbed by the silicon. For example, at column 2, lines 52-62,

a catalytically active metal, such as palladium, can be

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coated onto a silicon surface layer.... [W]hen in contact with a hydrogen-containing atmosphere, [the catalytically active metal layer] generates atomic hydrogen which quickly penetrates this [catalytically active metal] layer and is absorbed by the [silicon surface layer].

Other methods disclosed by Winstel for "generating atomic hydrogen" include "electrolysis" or "a sputtering-on process or a glow-discharge process" (column 3, lines 1-13). In contrast, Applicants' claimed process does not require any extraneous means for generating atomic hydrogen, since the dangling bonds of the silicon layer are by themselves able to bond hydrogen atoms. In the Advisory Action, the Examiner challenged this aspect of Applicants invention, stating "there is no evidence to show that individual hydrogen atoms are stored on the silicon substrate." However, such teachings are within Applicants' specification as filed, and statements made in Applicants' disclosure are accepted as proof, absent contrary evidence.

Absent any evidence to the contrary, we accept these statements [from Appellants' specification] that the claimed final moisture content is critical.

In re Clinton, 188 U.S.P.Q. 365, 367 (CCPA 1976), citing *Pines v. McAllister*, 38 CCPA 981, 988, 188 F.2d 388, 392, 89 USPQ 312, 315 (1951).

Though not required, Applicants attach hereto FTIR (Fourier-Transform Infra

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Red) spectroscopy results obtained from a feasibility study performed by Applicants, showing the presence of Si-H bonds at the surface of porous silicon prepared in accordance with their invention.

In view of the above, Applicants respectfully believe that the combination of Northrup and Winstel does not teach or suggest the system recited in Applicants' claim 1 nor any of the claims depending from claim 1, and therefore respectfully request withdrawal of the rejections under 35 USC §§102 and 103 based on Northrup.

Rejections based on U.S. Pub. No. 2004/0209144 to Kornilovich

Independent claim 8 and its dependent claims 9-14 were rejected as anticipated by Kornilovich or unpatentable over Kornilovich alone or in further view of U.S. Published Patent Application No. 2002/0172820 to Majumdar et al. (Majumdar) or U.S. Patent No. 6,040,230 to Anthony et al. (Anthony). Applicants respectfully request reconsideration of these rejections in view of the following comments.

Kornilovich teaches that the storage medium is for neutral/molecular hydrogen (H₂ molecules), and not hydrogen atoms as taught and claimed by Applicants.

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Kornilovich teaches that the neutral/molecular hydrogen is absorbed by physisorption, and not chemisorption as claimed by Applicants. Emphasis on "neutral hydrogen," "functionalized," "organic molecules," and "physisorption" can be found throughout Kornilovich.

Kornilovich stores neutral/molecular hydrogen on functionalized organic molecules on the exterior of the silicon nanowire (column). While the Advisory Action quotes Kornilovich as stating "the surface of the organic molecule branches, not only the surface of the stem nanowire that is used to physisorb gas molecules such as neutral hydrogen molecules" ([0013]), the interpretation of this statement is in question. Molecular hydrogen (H_2) does not adsorb (physisorption) onto a silicon surface, as reported in various recent scholarly works, including Dag et. al., Phys Rev B 72, 155404 (2005). The only way to get molecular hydrogen to condense onto a silicon surface is by chilling it to below the triple point of hydrogen at 15 K; but this is condensation, not absorption (physisorption) in accordance with Kornilovich, much less dissociative adsorption (chemisorption) in accordance with Applicants.

Finally, the Examiner argued in the Advisory Action

[Kornilovich's] silicon nanowires formed by chemical vapor deposition inherently have surfaces on the (111) plane and have a minimum energy configuration suitable for forming a

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crystal. Burden is on the applicant is [sic] show differences in product comparison.

The Examiner improperly equates Kornilovich's disclosed "silicon nanowire" to Applicants' claimed "silicon column." A nanowire is by definition periodic in one dimension only, and therefore not a crystal. From Whatis.com, a nanowire is defined as:

NANOWIRE: A nanowire is an extremely thin wire with a diameter on the order of a few nanometers (nm) or less, where 1 nm = 10⁻⁹ meters. Two processes in nanotechnology by which nanowires can be manufactured are suspension and deposition. A suspended nanowire is held up by the ends in an evacuated chamber, and then is chemically etched or bombarded with high-speed atoms or molecules to reduce its diameter. Another method involves indenting the surface of a wire in the center of a suspended span, raising the temperature, and then stretching the wire while it is near its melting point. A deposited nanowire is fabricated on a surface consisting of some non-conducting substance such as plastic or glass. The process is similar to that by which semiconductor chips are grown, except that the result is a linear (one-dimensional) structure rather than a flat (two-dimensional) or solid (three-dimensional) structure.

From Answers.com:

The nanowires can show peculiar shapes. Sometimes they can show noncrystalline order, assuming e.g. a pentagonal symmetry or a helicoidal (spiral) shape. Electrons zigzag

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along pentagonal tubes and spiral along helicoidal tubes. The lack of crystalline order is due to the fact that a nanowire is periodic only in one dimension (along its axis). Hence it can assume any order in the other directions (in plane) if this is energetically favorable.

Another reference, <http://en.wikipedia.org/wiki/Nanowire>, may be viewed as less formal but is nonetheless consistent. The application of crystal lattice theory, specifically Miller indices, such as $\langle 111 \rangle$ requires periodicity in as many dimensions as there are indices. Therefore the $\langle 111 \rangle$ plane simply does not apply to a nanowire, and therefore the statement that "[Kornilovich's] silicon nanowires formed by chemical vapor deposition inherently have surfaces on the (111) plane" is incorrect.

In view of the above, Applicants respectfully believe that Kornilovich or any combination of Kornilovich with Majumdar or Anthony cannot teach or suggest the system recited in Applicants' claim 8 or its dependent claims 9-14. Applicants therefore respectfully request withdrawal of the rejections under 35 USC §§102 and 103 based on Kornilovich.

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Attachment

FTIR (Fourier-Transform Infra Red)
spectroscopy results which show the
presence of Si-H bonds at the surface
of porous silicon.

